

## Heat-shield for Extreme Entry Environment Technology (HEEET) Development Status

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The Heat shield for Extreme Entry Environment Technology (HEEET) Project is a NASA STMD and SMD co-funded effort. The goal is to develop and mission infuse a new ablative Thermal Protection System that can withstand extreme entry. It is targeted to support NASA's high priority missions, as defined in the latest decadal survey, to destinations such as Venus and Saturn in-situ robotic science missions. Entry into these planetary atmospheres results in extreme heating. The entry peak heat-flux and associated pressure are estimated to be between one and two orders of magnitude higher than those experienced by Mars Science Laboratory or Lunar return missions. In the recent New Frontiers community announcement [1] NASA has indicated that it is considering providing an increase to the PI managed mission cost (PIMMC) for investigations utilizing the Heat Shield for Extreme Entry Environment Technology (HEEET) and in addition, NASA is considering limiting the risk assessment to only their accommodation on the spacecraft and the mission environment [1].

The HEEET ablative TPS utilizes 3D weaving technology to manufacture a dual layer material architecture. The 3-D weaving allows for flat panels to be woven. The dual layer consists of a top layer designed to withstand the extreme external environment while the inner or insulating layer by design, is designed to achieve low thermal conductivity, and it keeps the heat from conducting towards the structure underneath. Both arc jet testing combined with material properties have been used to develop thermal response models that allows for comparison of performance with heritage carbon phenolic. A 50% mass efficiency is achieved by the dual layer construct

compared to carbon phenolic for a broad range of missions both to Saturn and Venus.

The 3-D woven flat preforms are molded to achieve the shape as they are compliant and then resin infusion with curing forms a rigid panels. These panels are then bonded on to the aeroshell structure. Gaps exist between the panels and these gaps have to be filled with seams. The seam material then has to be bonded on to adjacent panels and also to the structure. The heat-shield assembly is shown in Figure 1. One of the significant challenges we have overcome recently is the design, development and testing of the seam. HEEET material development and the seam concept development have utilized some of the unique test capabilities available in the US. The various test facilities utilized in thermal testing along with the entry environment for Saturn and Venus missions are shown in Figure 2. The HEEET project is currently in its 3<sup>rd</sup> year of a four-year development. Figure 3 illustrates the key accomplishments to-date and the challenges yet to be overcome before the technology is ready for mission infusion. This proposed presentation will cover both progress that has been made in the HEEET project and also the challenges to be overcome that is highlighted in Figure 3. Objective of the HEEET project is to mature the system in time to support the next New Frontiers opportunity and we believe we are well along the way to mission infuse HEEET.

### Reference:

- (1) <http://newfrontiers.larc.nasa.gov/announcements.html>

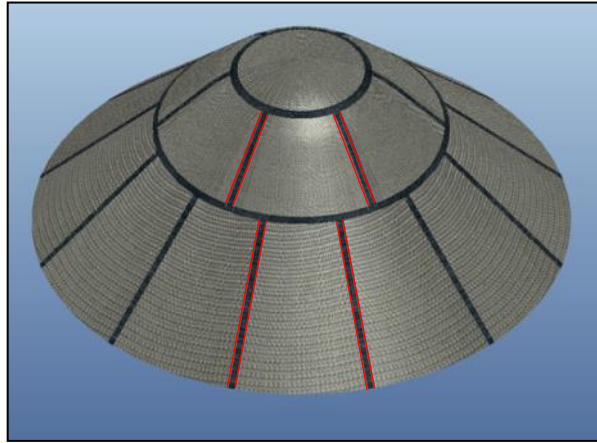


Figure 1. HEEET panels and seams integrated on to a structure has to be demonstrated to withstand  $> 5000+ \text{ W/cm}^2$  peak heating and stagnation peak pressures greater than 6 atmospheres.

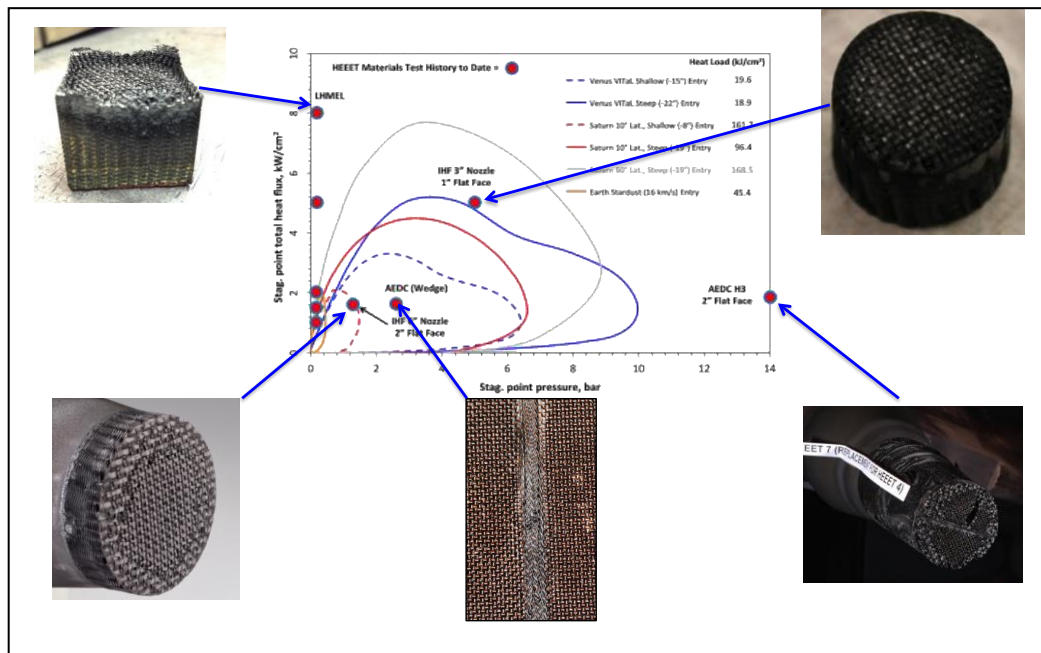


Figure 2. The numerous facilities, both arc jet and laser heated (LHEML) where tests have been conducted to assess the performance of and understand failure mode if any of the dual layer, 3-D woven, ablative TPS material along with seam concepts. These tests include stagnation point coupons as well as testing flat panels in a wedge configuration to test at combined (heat-flux, pressure and shear).

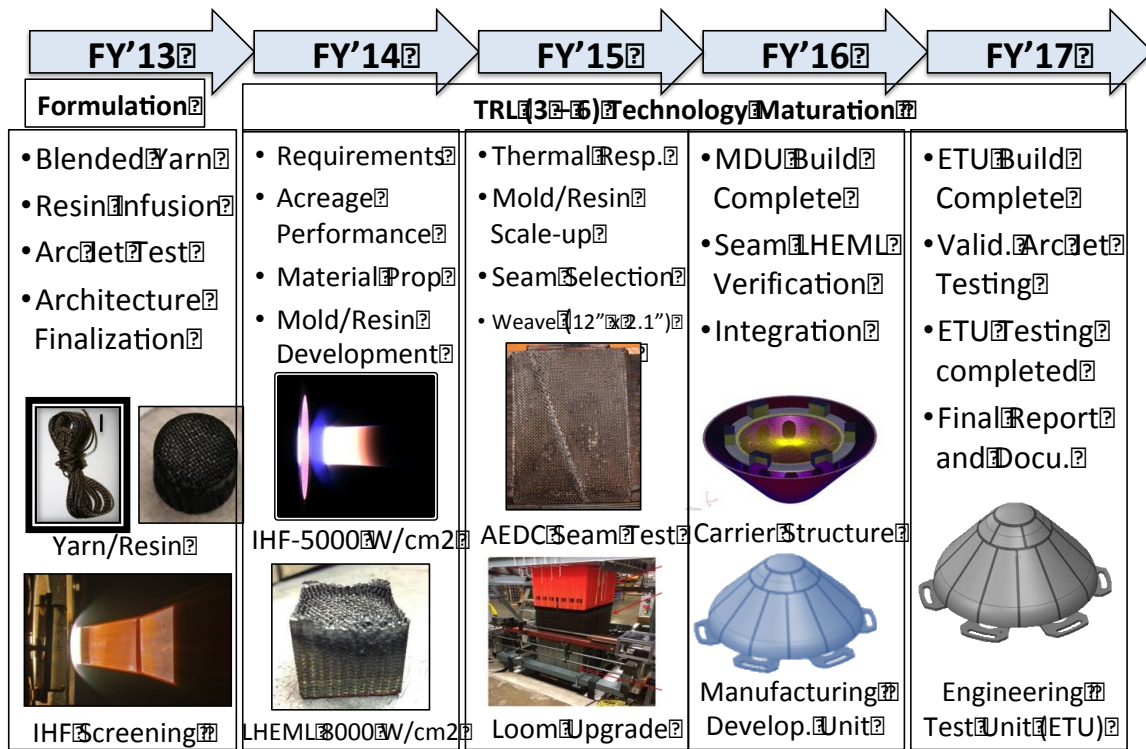


Figure 3. HEEET project went through a year of formulation and is currently in its 3<sup>rd</sup> year of a